Space Weather Technical Forecast

Issued on Thursday, 21 July 2022 at 13:14 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1/Minor Storms likely day 2 (22nd) and perhaps day 3 (23rd). Chance of M-flares (R1-R2 Radio blackouts) throughout. Chance of Active electron fluence day 1 (21st) and possibly day 4 (24th). Potential Earth-directed CME towards the end of the period - pending analysis.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the last 24 hours. There are currently nine active sunspot regions on the visible disc, however most of them are stable with no real magnetic complexity. None of the regions have been significantly active. However, AR3060, located near centre-disc, produced a peak C5.7 flare at 21/0111UTC, which was initiated by a filament eruption, this can be observed in SDO/AIA 304 imagery. This produced a complex CME, with potentially a full halo, which can be seen in LASCO imagery, although awaiting STEREO-A imagery for further analysis. Given the location of the sunspot and the filament lift-off, there is the potential for an Earth-directed component - pending analysis. No other Earth-directed CMEs were observed.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR and ACE at L1, was indicative of the tail end of a magnetic cloud, following a recent CME arrival (18th). Solar wind speeds constantly declined through the period, from 430 to 370km/s. Density was mostly average, with a steady rise to above average towards the end of the period, currently peaking at 18ppcc. The IMF (interplanetary magnetic field) Bt was mostly moderate, with a steady rise throughout, peaking at 11nT. The north-south component (Bz) was fluctuating between -8nT and +6nT but has recently become unremarkable and mostly positive. The phi angle was largely negative (towards the Sun). The net result of these solar wind measurements was a Quiet (Kp 0-2) geomagnetic activity.

Energetic Particles / Solar Radiation: The high energy proton flux (10 MeV), as measured by GOES16, was at background levels. High energy electron flux peaked at high level during the diurnal cycle, reaching 1920 pfu at 20/1620 UTC. The corresponding 24-hour integrated electron fluence remained below the Active threshold but showed a sharp rising trend, reaching 7.65e7 integrated pfu at 21/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Despite a large number of active regions, activity is expected to remain largely Low with an ongoing chance of isolated M-flares through the period.

Solar Wind / Geomagnetic Activity: Solar winds, initially slow-ambient, are expected to become elevated or perhaps strong in the early UTC hours of day 2 (22nd) under the combined influence of CH01/- and CH02/-, followed by a gradual decline on day 4 (24th). Geomagnetic activity is expected to be Quiet initially, but to become Unsettled and Active with isolated G1/Minor Storm intervals on day 2 (22nd) and perhaps early on day 3 (23rd). Activity easing back to Quiet to Unsettled on day 4 (24th). However, there is the potential for a Earth-directed

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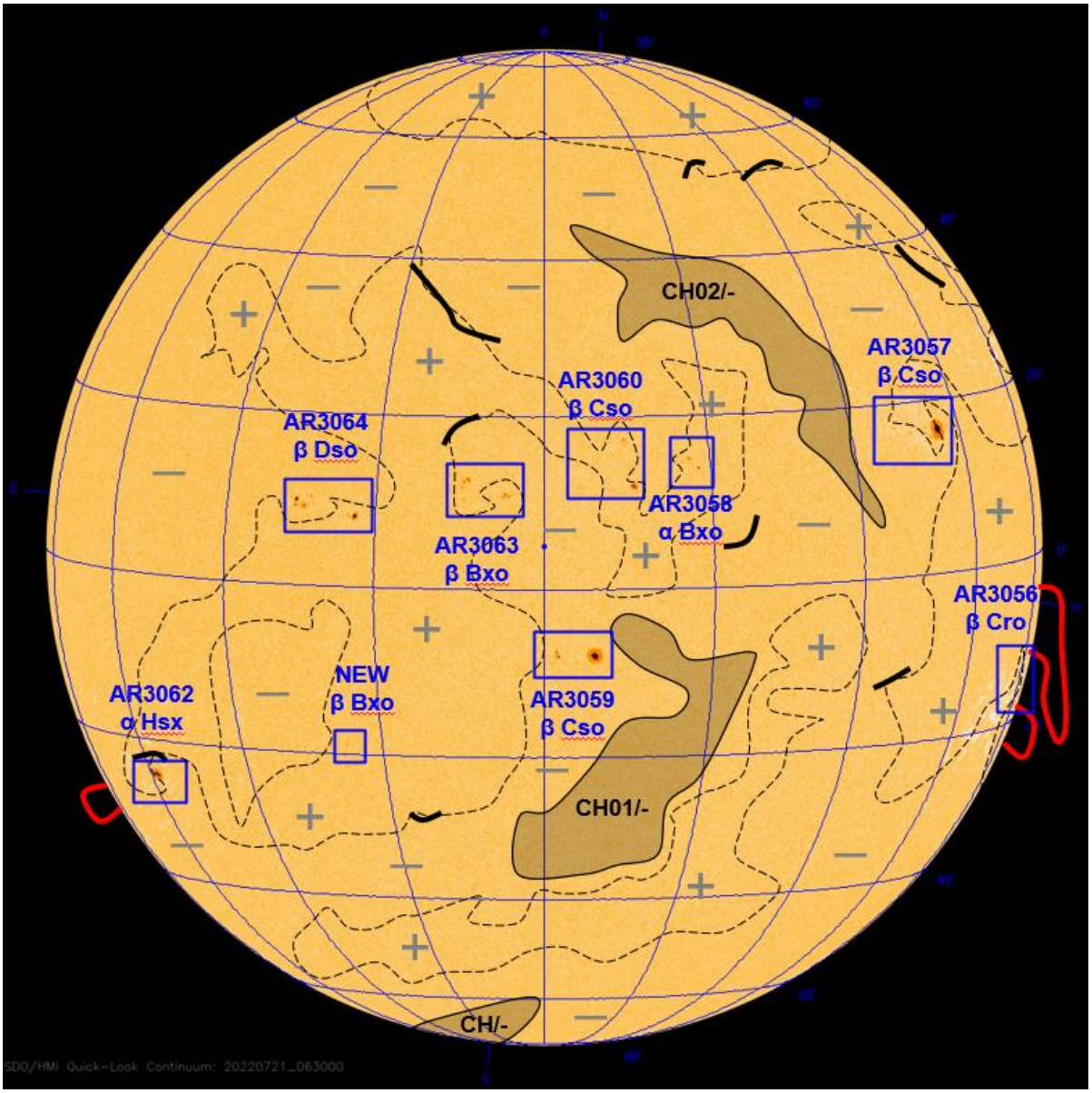
CME, after a recent filament eruption near AR3060, which may enhance geomagnetic activity towards the end of the period - pending analysis.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) is likely to remain at background levels. The high energy electron flux (greater than 2 MeV) should continue to reach high levels on day 1 (21st), before dropping following the onset of the high speed stream expected on day 2 (22nd). Flux levels rising again on day 3 (23rd) to exceed high levels on and day 4 (24th). The associated fluence is likely to rise above the Active threshold (1e8 integrated pfu) on day 1 (21st) and day 4 (24th). Uncertainty towards the end of the period, pending the analysis of the CME mentioned above.

Figure 1. Solar Analysis Valid 21/0630UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:
There are two reasonably sized coronal holes currently transiting across the western hemisphere, namely CH01/- and CH02/-. As they cover similar longitudes, it is reasonable to believe that their respective high speed streams will merge and arrive at the same time at Earth. These are recurring features that generated speeds of 550km/s on the previous rotation. However they look slightly larger this time around, extending further equator-ward and eastward. Therefore the associated high speed stream is anticipated to arrive earlier than persistence suggests and most likely in the early UTC hours of day 2 (22nd). It also seems reasonable to believe that elevated or perhaps strong (550-600km/s) solar wind speeds are to be expected on day 2 and day 3 (22nd and 23rd), possibly slowly easing on day 4 (24th).

Geomagnetic activity is expected to be Quiet initially, but to become Unsettled and Active with isolated G1/Minor Storm intervals on day 2 (22nd) and perhaps early on day 3 (23rd). Activity easing back to Quiet to Unsettled on day 4 (24th).

However, a recent C5 flare originating from AR3060 initiated a filament lift-off, located near center-disc, which has produced a complex CME, which is currently being analysed. This looks to have produced a faint partial halo, which can be seen in LASCO imagery, although awaiting further imagery from STEREO for a more detailed analysis. Given its location on the disc, this has the potential to be Earth-directed, pending analysis. This may enhance geomagnetic activity towards the end of the period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	60	20	20
Strong	G3	No	1	5	2	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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Figure 2 – MOSWOC ENLIL shows the arrival of fast wind on the 22nd.

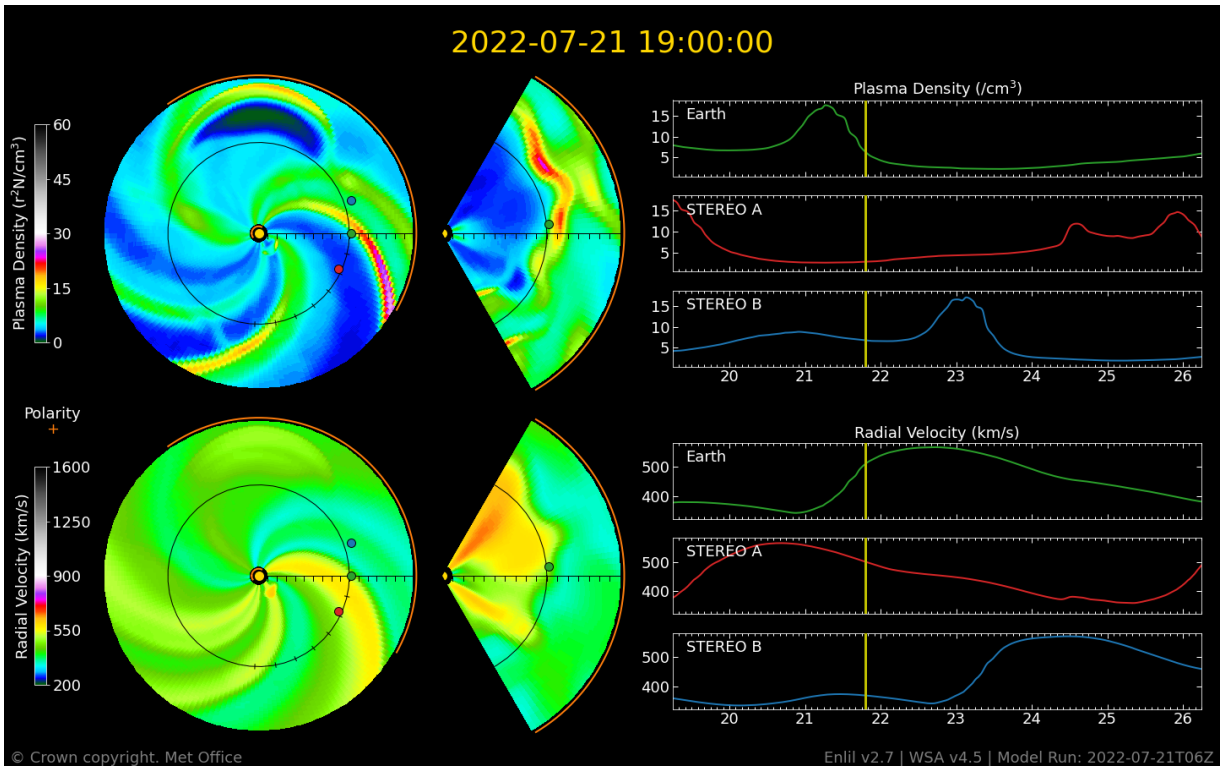
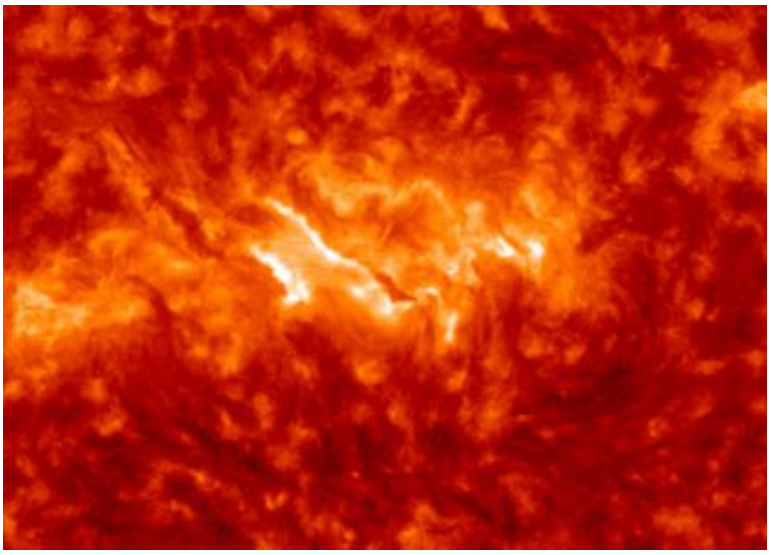


Figure 3: SDO/AIA 304 imagery (top) shows the filament lift-off near AR3060, at centre-disc.

SDO/AIA 94 image (middle) shows C5 flare, originating from AR3060.

SOHO LASCO C3 image (bottom left) shows the complexity of the CME, with a faint Full Halo visible (white dashed lines). Bulk of the plasma being launched to the northeast and southeast (shown by red dashed lines) as separate features. Dimming was evident in difference imagery (bottom right).



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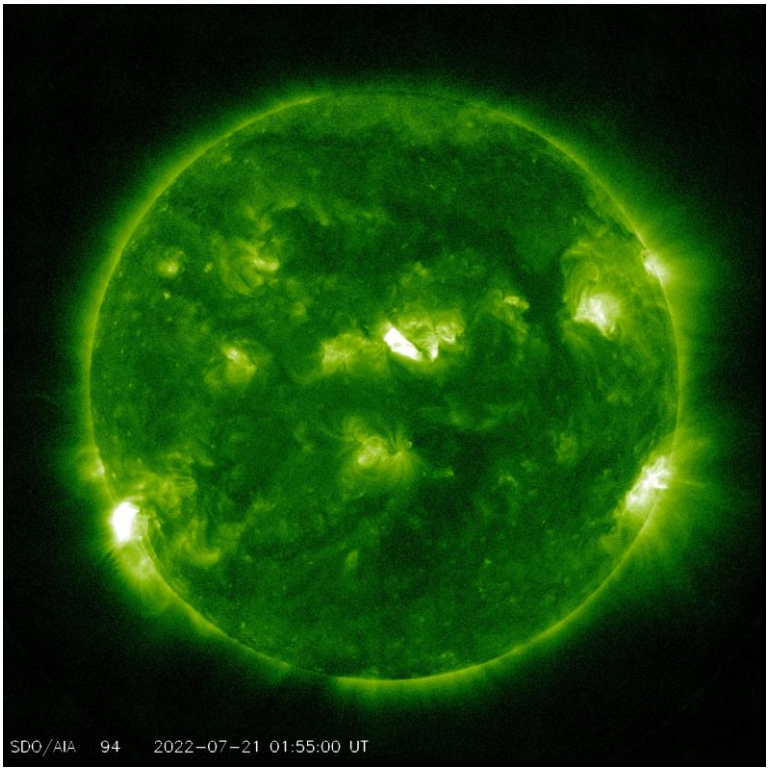

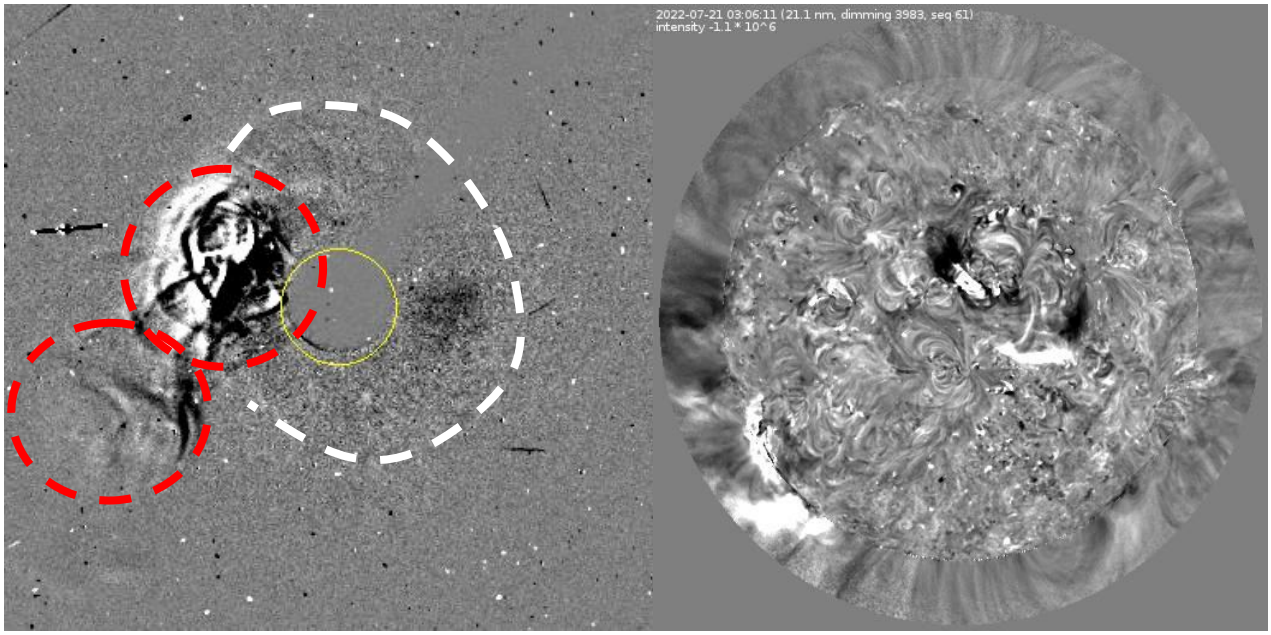

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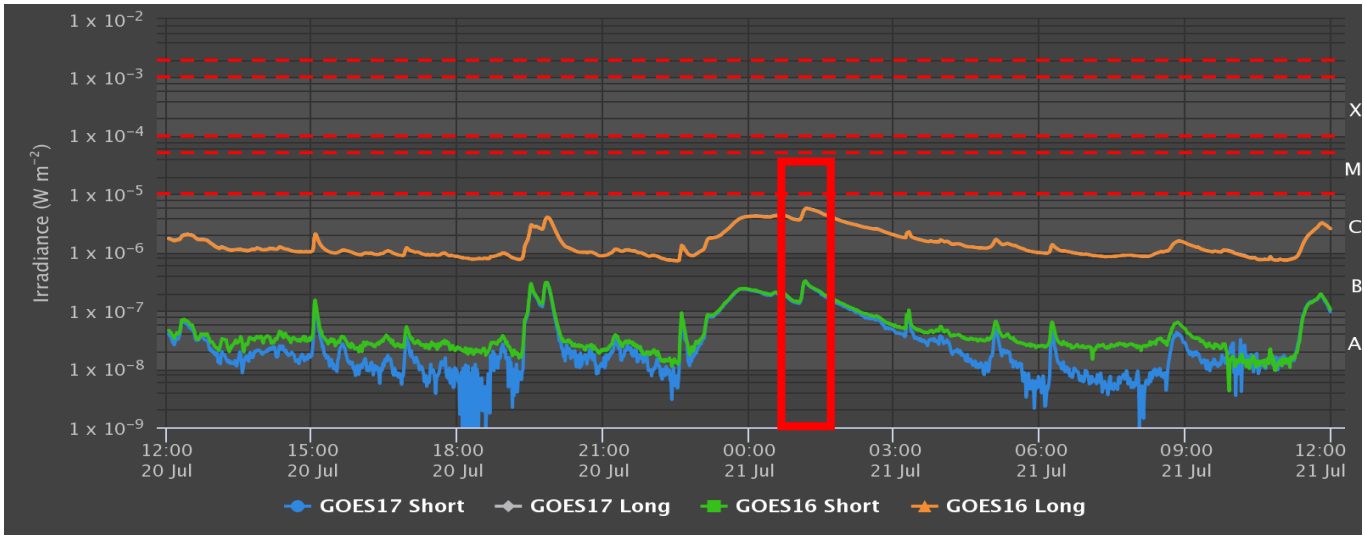
Radio Blackouts - X-Ray Flares:
Solar activity is currently Low, with the observed X-ray flux by GOES persisting at around C-class, with frequent small C1 flares and a couple of C3 flares, most of which originated from AR3056. However, a recent C5.7 flare originating from AR3060, near center-disc, initiated a filament eruption, which has produced a complex CME, with a possible partial halo seen in LASCO imagery. This is currently under analysis for any potential Earth-directed component, especially given its origin and location. Awaiting further imagery from STEREO for a more detailed analysis.

There are currently eight numbered sunspot regions on the visible disc, however most of them are stable with no real magnetic complexity. AR3057 is currently the largest region but it is mostly inactive and showing signs of decay. AR3059, the next one in size, currently on the southern centre disc, has the potential to develop further. AR3058, AR3060 and AR3063 are slowly weakening, some of their spots gradually fading. AR3064, in the northeast, has recently grown in size and complexity but also remains largely inactive. AR3062, in the southeast, is a simple unipolar region. AR3056 is somewhat more difficult to analyse as it approaches the southwest limb but remains largely unchanged. A newly unnumbered sunspot has recently emerged in the southeast, which is a simple bipolar region.

Despite a large number of active regions, activity is expected to remain largely Low with an ongoing chance of isolated M-flares through the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	25	25	25	25
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 4: GOES X-Ray flares – shows the C5 flare from AR3060 which produced a CME.



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) is currently at background levels. There is the potential for proton flux increasing due to the number of sunspot regions on the Earth-facing disc, including regions on or just over the west limb. However, these only give a very slight chance of proton flux reaching the S1 level (10 pfu).

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2MeV) electron flux as measured by GOES-16 has recovered from the recent CME and associated fast wind, peaking at 1920 pfu at 20/1620 UTC during the diurnal cycle. A similar cycle is expected to occur on day 1 (21st), giving a good chance for the corresponding 24 hour fluence to exceed the Active threshold. The arrival of the fast speed stream originating from CH01 and CH02 and a significant chance of a G1 / Minor Storm will however disturb this initial rise on day 2 (22nd), generating a temporary suppression of the electron counts. These may recover and perhaps exceed the high level on day 3 but we'll probably have to wait until day 4 to see a new equilibrium being achieved, with high flux returning for longer periods of time. Uncertainty towards to the end of the period, pending analysis of a potential Earth-directed CME.

The associated fluence is likely to rise above the Active threshold (1e8 integrated pfu) on day 1 (21st) and day 4 (24th). The latest REFM is not considered to give good guidance on this occasion.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	50	20	40	50
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	10

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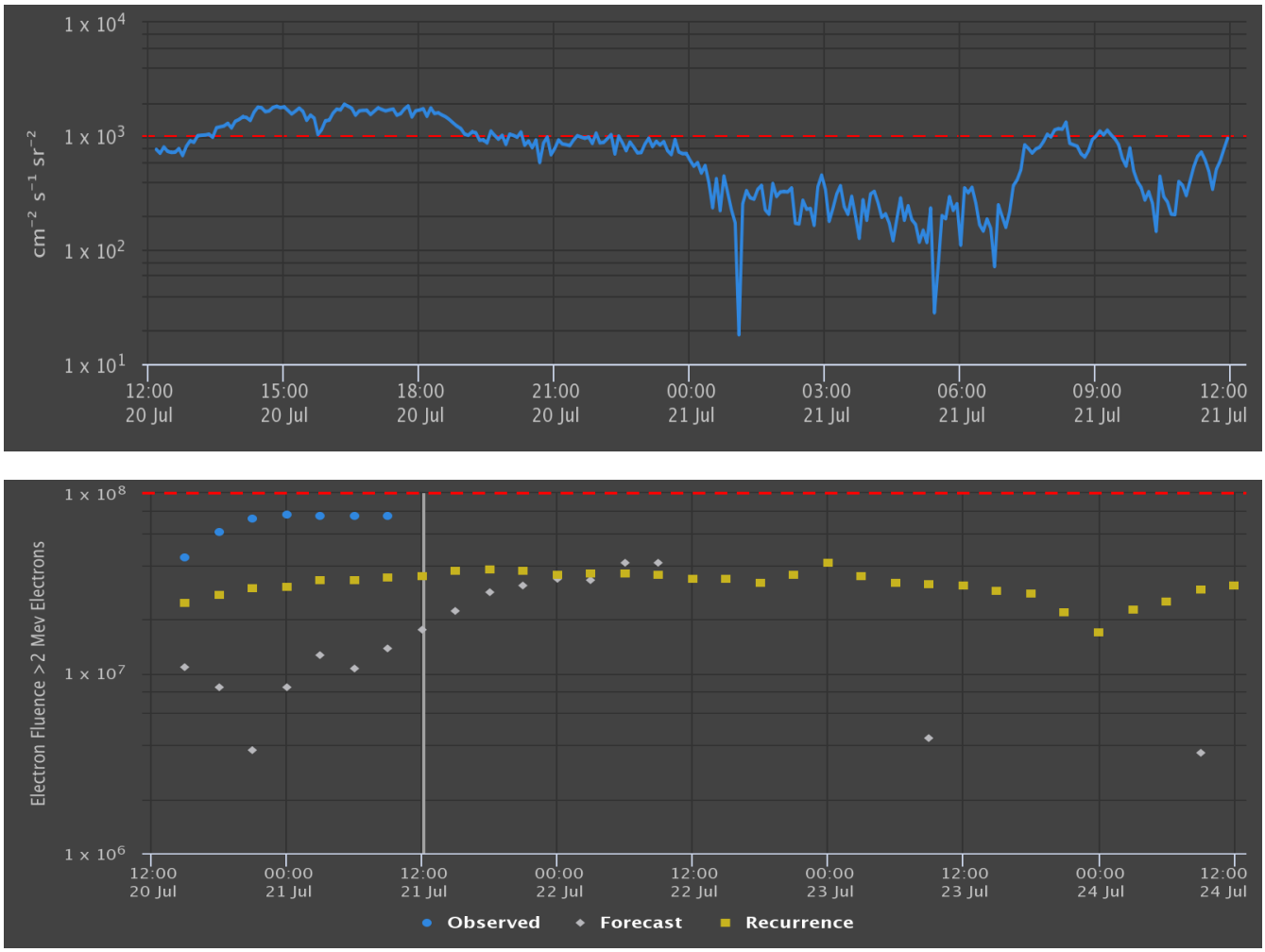
Figure 5: GOES-16 Electron flux and Electron Fluence REFM.



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